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Before the
Federal Communications Commission
Washington, D.C. 20554

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| In the Matters of<br><br>Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules | WT Docket No. 99-168 |
| and | |
| The Development of Operational, Technical and Spectrum Requirements For Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010 | WT Docket No. 96-86 |

To: The Commission

**EX PARTE COMMUNICATION OF THE FEDERAL LAW ENFORCEMENT WIRELESS USERS GROUP**

Filed by: The Federal Law Enforcement Wireless Users Group

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**EX PARTE COMMENTS OF THE FEDERAL LAW ENFORCEMENT WIRELESS USERS GROUP**

1. The Federal Law Enforcement Wireless Users Group (FLEWUG) respectfully submits the following ex parte comments regarding the Commission's Notice of Proposed Rulemaking *In the Matter of Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules* (Notice)[1] and its First Report and Order *In the Matter of the Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010* (1st R&O).[2] In these documents, the Commission directly addresses a number of issues, such as private wireless service providers in the 746–764 and 776–794 Megahertz (MHz) bands and systems emissions and interference standards that greatly interest the FLEWUG. The FLEWUG continues to take an active role in wireless communications issues with direct impact on its constituency, and on federal, state and local public safety agencies generally. Through these ex

[1] See *In the Matter of Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules*, WT Docket No. 99-168, FCC 99-97 (rel. June 3, 1999).
[2] See *In the Matter of the Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010*, WT Docket No. 96–86, FCC 98–191 (rel. September 29, 1998).

parte comments, the FLEWUG hopes to bring the benefits of its perceptions to the Commission as it decides the matters raised in the Notice and the 1$^{st}$ R&O.

## I. STATEMENT OF INTEREST

2. The FLEWUG consists of law enforcement and public safety officials from throughout the Federal Government.[3] An important aspect of the FLEWUG's mission is to develop a plan for an intergovernmental, shared-use public safety wireless communications network. The objective of this is to enable public safety agencies at all levels of government to respond to emergency situations in a coordinated, effective manner, thereby significantly increasing their potential ability to protect life and property. Building on the findings of the Public Safety Wireless Advisory Committee (PSWAC), the FLEWUG has made spectrum a priority, and has undertaken several spectrum-related activities to include making direct contributions to this and other Commission proceedings bearing on public safety spectrum. Any development affecting public safety communications, particularly those related to use and management of the 24 MHz of recently reallocated spectrum in the 764-776 and 794-806 MHz bands ("The 700 MHz Band"), directly and significantly interests the FLEWUG.

3. The FLEWUG is pleased to offer these ex parte comments in regard to the Notice and the 1st R&O. These dockets affect public safety's possible participation within the 700 MHz band, and the results of this proceeding could affect public safety's ability to receive additional needed spectrum in the future. As an entity working on behalf of public safety, the program determined that it would best serve the interests of the community by reserving comments for specific public safety issues raised by other commenters. The FLEWUG offers these ex parte comments to do so.

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[3] The FLEWUG consists of law enforcement and public safety officials from the Department of the Treasury, Department of Justice, Department of the Interior, Department of Agriculture, Department of Defense, Department of Health and Human Services, United States Postal Service, United States Postal Inspection Service, National Telecommunications and Information Administration, Federal Emergency Management Agency, Internal Revenue Service, Federal Bureau of Investigation, United States Secret Service, United States Coast Guard, United States Capitol Police, Drug Enforcement Administration, United States Park Police, Immigration and Naturalization Service, United States Customs Service, Bureau of Alcohol, Tobacco, and Firearms, United States Mint, National Communications System, Defense Information Systems Agency, National Security Agency, Federal Law Enforcement Training Center, Bureau of Engraving and Printing, United States Marshals Service, National Institute of Standards and Technology, United States Forest Service, United States Fish and Wildlife Service, Bureau of Prisons.

4. The FLEWUG will address the following areas in its ex parte comments filed on the Notice and 1st R&O: proposed channel plans for the recently reallocated public safety spectrum in the 746–764 and 776–794 MHz bands, the establishment of guard bands adjacent to public safety spectrum to prevent interference, and the establishment and adoption of technical standards governing interoperability.

## II. THE USE OF GUARD BANDS

5. The FLEWUG is concerned about interference between new public safety users and preexisting commercial users on the recently reallocated 24 MHz in the 700 MHz band. As the demand for spectrum increases exponentially as a result of the development and proliferation of commercial broadband wireless data technologies, numerous commercial wireless services have indicated a desire to operate such services on bands adjacent to the public safety spectrum that are now occupied by analog television broadcasters.[4] Lucent Technologies has stated that the 700 MHz band is particularly suited for fixed and mobile communications because it affords good building penetration and is not subject to loss from naturally occurring barriers.[5] Unless adequate protection is required, the FLEWUG is concerned that public safety providers will be faced with interference problems similar to those experienced by the City of San Diego, which has stated that it has already experienced interference from commercial users on the nearby 800 MHz band.[6]

6. At the request of the Public Safety National Coordination Committee (NCC) Steering Committee, the National Telecommunications and Information Administration (NTIA), an advisory member of FLEWUG, has investigated ways to prevent commercial spectrum users from interfering with public safety operations in the 700 MHz band. Although the FLEWUG will not endorse a specific band plan proposal, it generally believes that the use of guard or

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[4] *See* e.g. ex parte comments, WT Docket No. 99–168: Bell Atlantic, US West, Yahoo, and Microsoft (November 1999).
[5] *See* Lucent Technologies ex parte comments, WT Docket No. 99–168 (November 1999).
[6] *See* City of San Diego ex parte comments, WT Docket No. 99–168 (November 1999).

buffer bands, which has been advocated by a number of other parties, may prevent interference on the recently allocated public safety channels from commercial users using adjacent bands.

7. The FLEWUG asserts that establishing receiver interference protection limits and adjacent band emission limits in the 764–776 and 794–806 MHz bands will minimize interference.[7] The FLEWUG advocates that the interference protection limit for public safety receivers should be 6 decibels (dB) below the noise power level of the receiver. This position is based on a 1dB degradation in the receiver noise level. This conservative approach is warranted because the services to be allocated in the spectrum adjacent to the public safety spectrum and their associated technical characteristics are unknown. Also interruptions to public safety communications, for even a short time or to a limited extent, can jeopardize the lives and property of the public and the public safety providers.

8. Based on the interference protection limits for public safety receivers, the characteristics assumed for the adjacent band transmitters, and the interference scenarios considered, the FLEWUG recommends the following attenuation values to protect public safety receivers in the 764-776 and 794-806 MHz bands:

1) For transmitters with power levels above 1 Watt: 65 + 10 Log (Power);

2) For transmitters with power levels below 1 Watt: 65 dBc (dB relative to the carrier).[8]

9. In addition, the FLEWUG has examined the band plans proposed by Motorola, Inc.[9] (Motorola) and FreeSpace Communications, Inc.[10] (FreeSpace) to minimize potential interference from adjacent band operations.

10. To avoid interference Motorola has suggested creating a transition region between public safety users and commercial users by allocating four 1.5 MHz band segments adjacent to the 764–776 and 794-806 MHz bands for private land mobile radio (PLMR) service. The Personal

[7] *See* FLEWUG letter to Kathleen Wallman, NCC Chair, and accompanying recommendations regarding receiver protection limits, adjacent band emission limits, and examination of proposed band plans, November 17, 1999 (as revised, December 9, 1999) (ATTACHED).

[8] *Ibid.*

[9] *See* Motorola, Inc., ex parte presentations, WT Docket No. 99–168 (October 11, 1999; November 12, 1999).

Communications Industry Association (PCIA) has expressed support for this concept citing a shortage of available PLMR spectrum.[11] Various public safety entities nationwide have expressed the belief that the location of similar services, including PLMR users, adjacent to the public safety services bands, would tend to minimize interference.[12] As a part of its plan, Motorola suggests auctioning the transition regions to a band manager who would then redistribute the spectrum to private users on a contractual basis. Motorola contends that band managers would address interference issues through frequency coordination; and that economies of scale would develop and result in lower equipment prices for public safety users.

11. The FLEWUG agrees with Motorola that there may be potential benefits from allocating PLMR or other like services adjacent to the bands allocated for public safety. Allocating compatible services adjacent to public safety bands would minimize the potential for interference to the public safety receivers. Interference to public safety receivers could be managed effectively through a coordination process. This approach would create a region over which mobile and fixed commercial transmitters could attenuate adjacent band emissions to a level adequate to protect public safety receivers. Instead of establishing a guard band in which spectrum would remain vacant to protect public safety receivers, this approach would make efficient use of spectrum.

12. The FLEWUG has also evaluated the band plan advanced in recent months by FreeSpace. The FreeSpace Communications network will comprise handsets and modems that transmit data and voice via a wireless link to small antennas mounted on either existing transmission towers or small base stations located on house rooftops throughout a community. The base stations will be linked to the Internet through either wireline digital subscriber lines or other high-speed Internet connections and will have an expected range of 0.5 miles. FreeSpace proposes that, to protect public safety operations in the 764–776 and 794–806 MHz bands, transmitters operating in four 1.5 MHz band segments adjacent to public safety will be required to operate at a peak power

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[10] *See* FreeSpace Communications, Inc., ex parte presentations, WT Docket No. 99–168 (October 7, 1999; November 15, 1999).
[11] *See* PCIA ex parte presentation, WT Docket No. 99–168 (November 23, 1999).
[12] *See*, e.g. ex parte comments, WT Docket No. 99–168: Arizona Department of Public Safety, City of Chicago, City of El Cajon, City of Ft. Lauderdale, Maryland State Police, North County Dispatch (Telecordia), (November 1999).

spectral density (PSD) that does not exceed 4 miliwats per kilohertz (mW/kHz).[13] FreeSpace also proposes that to further minimize interference, the actual power of the transmitter be set dynamically using active power control technology.[14]

13. The FLEWUG believes that allocating bands adjacent to the public safety spectrum to a service employing low–power transmitters would be an alternative approach to protect public safety operations. Low–power transmitters should be able to achieve adjacent band emission limits adequate to protect public safety receivers with minimum impact and cost to their system design. Although FreeSpace has amended its plan to include the provision of transmitter locations in a real-time position–oriented database,[15] the FLEWUG remains concerned that the location of these devices and the number of devices in a given geographic area may be unknown, making coordination difficult. Furthermore, based on the anticipated high-density use of fixed and mobile low-power transmitters, the potential adjacent band interference to public safety receivers must take into account the effect of aggregate interference from multiple transmitters. To reduce the effects of aggregate interference, provisions could be adopted to ensure that the aggregate power of the transmitters never exceeded the power limits of a single transmitter. Limitations on the duty cycle of the transmitters could also be adopted.

14. The Association of Public–Safety Communication Officials – International, Inc. (APCO) concluded on November 17 that FreeSpace had not yet submitted sufficient technical data to the record to permit evaluation of the technical feasibility of its proposal.[16] FreeSpace has recently submitted more information about its system via several ex parte presentations during late November 1999. However, some of the information appears to be inconsistent, making a complete and accurate evaluation of the FreeSpace proposal difficult as of yet. As additional information is forthcoming, the FLEWUG will endeavor to re evaluate the plan and comment accordingly.

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[13] *See* FreeSpace Communications ex parte Presentation, *Service rules for 746/764/776–794 MHz Bands*, WT Docket No. 99–168 (November 10 and 12, 1999).

[14] *See* FreeSpace Communications ex parte memorandum responding to ex parte comments by Motorola, November 11, 1999 (November 15, 1999).

[15] See FreeSpace Communications, Inc., ex parte comments, WT Docket No. 99–168 (November 17, 1999).

[16] *See* APCO Ex parte comments, Docket No. WT 99–168 (November 16, 1999).

## III. PROPOSED CHANNEL PLANS

15. The FLEWUG disagrees with the proposed modifications to the channel plan for the public safety spectrum at 764–776 MHz and 794–806 MHz put forward in the Petition for Reconsideration to WT Docket No. 96–86 by Ericsson, Inc.[17] This petition proposes modifications to the channel plan developed as part of the 1st R&O. Ericsson suggests that up to four 6.25 kHz narrowband channels be aggregated to form a 25 kHz channel throughout the public safety spectrum. Ericsson further proposes that to accommodate wideband video and data in this band, the aggregation of 50 kHz channels should be increased from three (150 kHz) to twelve (600 kHz). These, Ericsson argues, would ensure that a full range of broadband technology and equipment would be available to the public safety community.

16. Although the FLEWUG agrees in part with Ericsson that the broadest possible range of equipment should be made available to the public safety community, the FLEWUG does not support the creation of 600 kHz of aggregated channels in the 700 MHz band.

17. Specifically, the FLEWUG object because the suggested creation of 12 wideband data and video channels in the 700 MHz band could give the impression that public safety wideband data and video requirements can be met through current allocations. On the contrary, creating wideband channels in addition to the current 150 kHz channels in the 700 MHz band displace the critical-function land mobile radio (LMR) and other narrow–band applications for which the current 24 MHz has long been desperately needed.

[17] *See* Ericsson ex parte meeting notice, Docket No. WT 96–86 (September 13, 1999). *See also* Letter to Kathleen M.H. Wallman, Esq., NCC Chair (September 14, 1999).

## III. INTEROPERABILITY STANDARDS

18. The FLEWUG has adopted, by vote, the ANSI TIA/EIA 102 (Project 25 Phase I) as the digital interoperability standard for radio communications.[18] This standard comprises the American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Electronics Industry Alliance (EIA) 102 BAAA–1998 Frequency Division Multiple Access (FDMA) Common Air Interface (CAI) standard and the ANSI/TIA/EIA102.BABA–1998 Vocoder Description standard.[19] The NCC Technical Subcommittee has also recommended adoption of this standard, which is based on a 12.5 kHz channel.[20]

19. In an ex parte comments to the Commission, the American Association of State Highway and Transportation Officials (AASHTO), The Forestry–Conservation Communications Association (FCCA), the International Association of Fire Chiefs, Inc. (IAFC), and the International Municipal Signal Association (IMSA) have all suggested that the NCC undertake development of a third interoperability standard in addition to Project 25 and Terrestrial Trunked Radio (TETRA).[21]

20. The FLEWUG opposes development of a third interoperability standard. Project 25 and TETRA each required ten years and direct coordination with public safety users to develop. The proposed NCC role in standards development would require substantial public expenditures at all levels of government, will likely result in a duplication of existing standards development efforts, might result in incompatible standards, and could further delay the use of the 700 MHz band for public safety purposes.[22] Based on the PSWAC recommendation, an additional 73.5 MHz remains to be allocated to the public safety[23]. The FLEWUG maintains that broadband services should be located in this additional spectrum.

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[18] *See* FLEWUG Petition for Reconsideration and Clarification, WT Docket No. 96–86 (December 2, 1998) at Paragraph 33.
[19] *Ibid.*
[20] NCC Technology Subcommittee meeting, New York, New York, November 18, 1999.
[21] See AASHTO, FCCA, IAFC, IMSA ex parte communication, WT Docket No 96–86 (October 8, 1999).
[22] FLEWUG Petition at Para. 33, *supra.*
[23] *Public Safety Wireless Advisory Committee (PSWAC) Final Report*, September 11, 1996, at p. *3.*

21. Moreover, as APCO has observed, no 6.25 kHz equipment is being developed or tested.[24] Indeed, an informal survey of equipment manufacturers, which included Motorola, Ericsson, and E. F. Johnson, conducted at a November 18, 1999, meeting of the NCC Technology Subcommittee in New York City, revealed that none of the companies currently has 6.25 kHz equipment available in the U. S. market. Further, although there was some speculation, none of the companies indicated that they anticipated bringing such products to market within the next five years.[25]

## IV. CONCLUSION

22. In summary, the FLEWUG considers guard bands a viable option to protect public safety users in the 764–776 and 794–806 MHz bands from interference. The FLEWUG maintains that adequate adjacent channel protection must be mandated by the Commission to ensure that critical public safety functions are not interfered with at any time, to any extent, or for any duration.

23. The FLEWUG asserts that the Commission should not permit aggregation of spectrum into 600 kHz channels in the 700 MHz band. Any such action would be at the expense of providing general and interoperability spectrum for voice LMR and would create the erroneous impression that the need for wideband spectrum could be met by locating these services in the 700 MHz band, rather than through the allocation of additional spectrum.

24. Finally, the FLEWUG respectfully urges the Commission to formally adopt TIA/EIA-102 (Project 25) vocoder and CAI interoperability standards for public safety wireless radio communications.

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[24] APCO ex parte comments, WT Docket No. 99–168 (October 28, 1999).
[25] NCC Technology Subcommittee meeting, *supra*.

25. The FLEWUG commends the efforts of all commenters to this Notice and R&O and respectfully requests the Commission to carefully consider the FLEWUG's positions herein submitted in light of the comments propounded by others.

Sincerely,

James J. Flyzik

Deputy Assistant Secretary (Information Systems) and
Chief Information Officer, Department of the Treasury, and
Vice Chair, Government Information Technology Services (GITS) Board

FEDERAL LAW ENFORCEMENT
WIRELESS USERS GROUP
WASHINGTON. D.C.

December 8, 1999

**By Hand Delivery**

Kathleen Wallman, Chair
National Coordination Committee
445 12th Street, NW
Suite 321
Washington, DC 20004

Ms. Wallman,

During the National Coordination Committee (NCC) conference call held on October 12, the NCC Steering Committee had requested that the Federal partners provide assistance in the development of a public safety receiver interference protection limit. On November 17, in response to this request, the Federal Law Enforcement Wireless Users Group (FLEWUG) provided its recommendations concerning: 1) a methodology that could be used in the development of a receiver interference protection limit for the public safety receivers in the 764-776/794-806 MHz bands, 2) a proposal for adjacent band emission limits to protect public safety receivers from yet-to-be determined transmitters, and 3) an examination of the proposed band plans.

The recommendations were presented at the NCC meeting in New York on November 18. Based on comments received during or pursuant to the meeting, the NTIA, acting in its capacity as an advisor to the FLEWUG, modified the analysis in the areas of: 1) distances and antenna heights considered in the analysis, 2) propagation model used in the analysis, and 3) adjacent band emission limits specified in terms of above 1 W and below 1 W. The revised recommendations and supporting technical material are provided in the enclosed document, which will also be provided as an attachment to the FLEWUG's ex parte comments pursuant to WT Docket Nos. 96-86 and 99-168.

Any questions on these matters can be directed to the undersigned.

Sincerely,

Julio R. Murphy
Co-Chair, FLEWUG
Department of the Treasury

Derek M. Siegle
Co-Chair, FLEWUG
Department of Justice

Enclosure

## (ATTACHMENT TO LETTER FROM FLEWUG REPRESENTATIVE)

## FLEWUG RECOMMENDATIONS

Based on the attached analysis, the following recommendations are submitted on behalf of the Federal Law Enforcement Wireless Users Group:

1. The interference protection limit for public safety receivers should be 6 dB below the noise power level of the receiver. This is based on a 1 dB degradation in the receiver noise level. This conservative approach is warranted because the services to be allocated in the spectrum adjacent to the public safety spectrum and their associated technical characteristics are unknown.

2. Based on the interference protection limits for public safety receivers, the characteristics assumed for the adjacent band transmitters, and the interference scenarios considered, the following attenuation values are recommended to protect public safety receivers from the adjacent band emissions of fixed and mobile transmitters:

- For transmitters with power levels above 1 Watt: 65 + 10 Log (Power)

- For transmitters with power levels below 1 Watt: 65 dBc (dB relative to the carrier)

3. There are benefits in allocating a service such as the Private Mobile Radio Service or other like services adjacent to the bands allocated for public safety:

- allocating compatible services adjacent to the public safety bands would minimize the potential for interference to the public safety receivers;

- interference to public safety receivers can be managed effectively through a coordination process;

- creates a region over which mobile and fixed commercial transmitters can attenuate adjacent band emissions to a level adequate to protect public safety receivers;

- instead of establishing a guard band where spectrum would lie fallow to protect public safety receivers this approach would make efficient use of the spectrum.

4. Allocating the spectrum adjacent to the public safety spectrum to a service employing low power transmitters is another alternative to protect public safety operations that has both benefits and drawbacks:

- lower power transmitters should be able to achieve adjacent band emission limits adequate to protect public safety receivers with minimum impact and cost to their system design;

- since the location of these devices and the number of devices in a given geographic area may not be known possibly making coordination difficult;

- based on the anticipated high-density use of fixed and mobile low power transmitters, the potential adjacent band interference to public safety receivers must take into account the effect of aggregate interference from multiple transmitters. To reduce the effects of aggregate interference, provisions could be adopted in the service rules that will ensure that the aggregate power of the transmitters never exceeds the power limits of a single transmitter. Limitations on transmitter duty cycle could also be established.

## ATTACHMENT

## INTRODUCTION

During the National Coordination Committee (NCC) conference call held on October 12, the band plans proposed by Motorola and FreeSpace Communications were discussed. Both bands plans are similar in that they propose to allocate a segment of the spectrum adjacent to the 764-776/794-806 MHz spectrum allocated for public safety (1.5 MHz in the Motorola plan and 1.5 MHz in the FreeSpace plan) to a compatible or low power service to create a "transition zone" between public safety and potentially incompatible commercial uses of the band. The NCC Steering Committee members suggested that it would be beneficial to establish a receiver interference protection limit for the public safety receivers operating in the 764-776/794-806 MHz bands. The receiver interference protection limit could then be used to justify a band plan proposing suggested allocations of the services in the band segments that are adjacent to the 764-776/794-806 MHz public safety spectrum. The NCC Steering Committee recommended that the Federal partners provide assistance in the development of a public safety receiver interference protection limit. This paper provides: 1) a methodology that could be used in the development of a receiver interference protection limit for the public safety receivers in the 764-776/794-806 MHz bands, 2) a proposal for adjacent band emission limits to protect public safety receivers, and 3) an examination of the proposed band plans. To the extent possible TSB 88, which is an industry accepted standard, will be used in the analysis contained in this document.[1]

## METHODOLOGY TO DEVELOP RECEIVER INTEFERENCE PROTECTION LIMITS FOR PUBLIC SAFETY RECEIVERS

### Receiver Interference Threshold

The level of interference that is acceptable for a receiver is affected by a number of factors such as the minimum propagation loss between the transmitter and receiver, the probability that a interfering transmitter is at a distance from the public safety receiver where it will cause interference and the probability that the public safety receiver is close to it's limit of coverage. Many of these factors are difficult to estimate. Law enforcement and public safety systems should be designed to support the lowest effective radiated power subscriber set intended for primary usage. In most instances this will necessitate systems be designed to support handheld/portable operation. In these instances it is recommended that the lowest practical power level radio be assumed to determine system performance in a prescribed area of operation.[2]

To develop an interference protection limit for the public safety receivers in the 764-776/794-806 MHz bands a noise limited system will be assumed. A noise-limited

[1] TIA/EIA Telecommunications Systems Bulletin TSB 88, Wireless Communications Systems Performance in Noise and Interference-Limited Situations – Recommended Methods for Technology-Independent Modeling, Simulation, and Verification, January 1998 (hereinafter TSB 88).

[2] TSB 88 at 13.

system is defined as one in which the performance is limited by the receiver noise level. In this case, the carrier-to-noise ratio (C/N) is only slightly greater than the minimum required for acceptable performance. In a noise-limited system, the interference level can be referred to the noise level and an interference-to-noise ratio (I/N) threshold can be used as the criterion for acceptable performance of the receiver. Since the threshold is based only on the noise level of the receiver the assumption of a noise limited system will result in a conservative interference protection limit that is somewhat independent of the receiver technology employed. A conservative approach is warranted because the services to be allocated in the spectrum adjacent to the public safety spectrum and their associated technical characteristics are unknown. Furthermore, the Notice of Proposed Rulemaking (NPRM)[3] and the legislative history[4] make it clear that in developing the rules for services that will operate in the 746-764 and 776-794 MHz bands, the Commission should ensure that public safety communications operating in the adjacent bands are not subject to interference from new services.

The relationship between the I/N threshold ($I/N_t$) and the C/N is given in the equation below:

$$I / N_t = 10\mathrm{Log}(10^{M_I/10} - 1)$$

The interference margin ($M_I$) is defined by:

$$M_I = C/N - C/(N+I)$$

where

C/N is the carrier-to-noise ratio in the absence of interference (dB);
C/(N+I) is the carrier-to-(noise plus interference) ratio (dB).

An interfering transmitter can increase the noise floor of the public safety receiver causing degraded or lost communication. In the 764-776/794-806 MHz bands digital technology is to be employed. For a digital receiver, the bit error rate (BER) performance is directly related to the receiver noise level by the energy per bit per Hertz ($E_b/N_0$). An increase in the receiver noise level will decrease the $E_b/N_0$ resulting in an increase in the BER. Establishing an interference threshold that is equal to or less than the receiver noise level is a common approach for digital receivers. In order to protect public safety receivers in the 764-776/794-806 MHz bands a 1 dB increase in the receiver noise floor will be permitted. Using the equation for I/N threshold the 1 dB increase in the receiver noise floor results in an interference threshold of $I/N_t = -6$ dB. This means that the interference must be kept at least 6 dB below the noise level of the public safety receivers in the 764-776/794-806 MHz bands.

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[3] *Service Rules for the 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules*, Notice of Proposed Rulemaking, WT Docket No. 99-168 (released June 3, 1999) (hereinafter NPRM).

[4] Balanced Budget Act of 1997, Conference Report to Accompany H.R. 2015, 105th Cong., 1st Sess., Report 105-217, at 580 (July 30, 1997).

**Receiver Noise Power Level**

As described in TIA/EIA TSB88, the receiver noise power level includes external environmental noise, transmission line noise, and internal receiver noise. A standard method of computing the total system noise power is to find the equivalent noise system temperature ($T_{SYS}$) , which is equal to the noise temperature of the antenna ($T_{ANT}$) plus the noise temperature of the receiver ($T_R$). ($T_{ANT}$ accounts for both external environmental and transmission line noise). The total receiver noise power N, in dBW, is then given by:

$$N = 10 \text{ Log } (kT_{SYS}B)$$

where

k is Boltzman's constant $1.38x10^{-23}$ (J/K);
$T_{SYS}$ is $T_{ANT}+T_R$ (K);
B is the receiver bandwidth (Hz).

As stated in TSB88 the receiver's Equivalent Noise Bandwidth (ENBW) should be used for the receiver bandwidth. Table 3 in Annex A of TSB88 provides values of ENBW for various configurations.

The receiver noise temperature is calculated using the standard formula:

$$T_R = T_0 \,(10^{(F/10)} - 1)$$

where

$T_0$ is standard temperature of 290 (K);
F is the receiver noise figure (dB).

The antenna noise temperature is given by:

$$T_{Ant} = [290(L_{CR} - 1) + T_{EVMT}]/L_{CR}$$

where

$L_{CR}$ is the receiver cable loss factor;
$T_{EVMT}$ is the external environmental noise temperature.

The external environmental noise temperature is determined using the following equation:

$$T_{EVMT} = [10^{(N_{EVMT}-204)/10}] / k$$

The term $N_{EVMT}$ is the frequency dependent environmental noise level, which takes into account atmospheric (lightning), man-made (urban, suburban, and rural), and galactic noise sources. A C++ program is provided in Annex A that can be used to compute the total receiver noise power. In this program the curves used for the external environmental noise level were derived from ITU-R study group recommendations, and represent measured data for the worst times/worst locations, (Noisy/Urban), best times/best locations (Quiet/Rural), and a median range (Average/Suburban).[5]

**Calculation of the Interference Protection Limit for Public Safety Receivers**

To compute the interference thresholds for the public safety receivers in the 764-776/794-806 MHz bands the following parameters will be used:

Frequency: 764 MHz
Bandwidth: 6.25 kHz (ENBW: 5.7 kHz)
Cable Loss: 1 dB
Noise Figure: 9 dB

Using the parameters given above, the total receiver noise power is found to be:

Rural: -127.85 dBm
Suburban: -127.78 dBm
Urban: -127.59 dBm

At 700 MHz the contribution from external environmental noise is negligible. The total receiver noise power is approximately:

$$N = -128 \text{ dBm}$$

Using the I/N threshold developed earlier the interference protection limit for the public safety receivers is given by:

$$I = N + I/N_t = -128 - 6 = -134 \text{ dBm}$$

**THE DEVELOPMENT OF ADJACENT BAND EMISSION LIMITS TO PROTECT PUBLIC SAFETY RECEIVERS**

There are no standardized interference scenarios for public safety operations. To develop the adjacent band emission limits required to protect public safety receivers in the 764-776/794-806 MHz bands two interference scenarios will be considered: 1) base-to-mobile and 2) mobile-to-mobile.

**Base-to-Mobile Scenario.** The interfering signal power level (I) from transmitters in the adjacent 746-764/776-794 MHz bands at the input of a public safety receiver is found by the following equation:

$$I = EIRP - P_{AdjBand} + G_R - L_P - L_{CR}$$

where

[5] Recommendation ITU-R PI.372-6 Radio Noise.

EIRP is the equivalent isotropically radiated power density of the transmitter operating in the 746-764/776-794 MHz band (dBm/6.25 kHz);
$P_{AdjBand}$ is the adjacent band attenuation of the transmitters operating in the 746-764/776-794 MHz bands (dB);
$G_R$ is the public safety receiver antenna gain (dBi);
$L_P$ is the propagation loss between the transmitter operating in the 746-764/776-794 MHz bands and the public safety receiver in the adjacent band (dB);
$L_{CR}$ is the cable/insertion loss of the transmitter system (dB).

To determine the adjacent band emission limit required to protect public safety receivers for the base-to-mobile scenario, a nominal transmitter EIRP of 50 Watts (3 Watt and 12 dBi antenna gain) in a 1 MHz bandwidth will be used. A value of 2 dB will be used for the cable/insertion loss of the transmitter. The public safety receiver antenna gain is assumed to be 0 dBi and the antenna height is 2 meters.

The following equation will be used to compute the propagation loss, based on the propagation in TSB 88:

$$L_P = 20 \text{ Log } F + 20 \text{ Log } S - 27.55 + L_{Clutter} + L_{Fresnel} + L_{Reflection}$$

where F is the frequency of the transmitter, in MHz, and

$$S = (D^2 + )h^2)^{0.5}$$

where D is the horizontal distance separation between the transmitter and receiving meters and )h is the vertical separation in the antenna height between the transmitter and receiver antennas in meters.

The term $L_{Clutter}$ is the local clutter loss attenuation factor. This factor is a function of frequency and is based on data from the land use/land cover database that is currently available from the Department of the Interior Geological Survey. Values for the local clutter loss attenuation factor depend on frequency and whether the environment is residential, mixed urban/buildings, or commercial/industrial.[6] A value of 10 dB will be used in this analysis.

The term $L_{Fresnel}$ represents the partial Fresnel zone obstruction loss. This factor is path specific and cannot be included in this analysis.

The term $L_{Reflection}$ is the attenuation due to reflections. The reflection attenuation will vary as a function of the transmitter and receiver antenna heights and the distance separation between the transmitter and receiver. The combination of the direct and reflected rays give rise to an attenuation pattern with peaks and nulls that follow the sin function with an argument of $2\pi h_t h_r/\lambda d$. When the transmitter and receiver antenna heights are much less that the distance separation between the transmitter and receiver (*i.e.*, $h_t$, $h_r \ll d$) the argument of the sin function is small and thus can be replaced by its

[6] TSB 88 Annex A Table 12.

argument. The greater the distance separation between the transmitter and receiver, the larger the resulting reflection attenuation. Since the antenna heights will vary and the distance separation considered are relatively short, the reflection attenuation will not be included in this analysis.

Assuming a horizontal distance separation of 250 meters, a vertical separation of 50 meters and a frequency of 746 MHz the propagation loss is 88 dB.

To determine the adjacent band emission level required to protect a public safety receiver the interference power level will be set equal to the receiver interference threshold of –133 dBm. The adjacent band attenuation required to protect public safety receivers is found to be:

$$P_{AdjBand} = -I + EIRP + G_R - L_P - L_{CR} = -(-134) + 24.9 + 0 - 88 - 2 = 68.9 \text{ dB}$$

**Mobile-to-Mobile Scenario.** To determine the adjacent band emission limit required to protect public safety receivers for the mobile-to-mobile scenario a transmitter EIRP of 1 watt in a 1 MHz bandwidth and an antenna height of 2 meters will be assumed. A value of 2 dB will be used for the cable/insertion loss of the transmitter. The public safety receiver antenna gain is assumed to be 0 dBi and the antenna height is 2 meters.

The same general equations used in the previous section will be used to determine the adjacent band emission level required to protect public safety receivers. A distance separation of 50 meters will be assumed between the mobile transmitter and the public safety receiver resulting in a propagation loss of 73.8 dB. The adjacent band attenuation required to protect public safety receivers is found to be:

$$P_{AdjBand} = -I + EIRP + G_R - L_P - L_{CR} = -(-134) + 7.9 + 0 - 73.8 - 2 = 66.1 \text{ dB}$$

## EXAMINATION OF THE PROPOSED BAND PLANS FOR THE 746-806 MHz BAND

### Motorola Band Plan

In filings with the Commission Motorola has demonstrated that highly dissimilar services operating in close proximity raise the potential of interference. Motorola described how traditional high-power broadcast operations are incompatible with low power mobile services. Motorola also provided analysis demonstrating the difficulties that traditional low-site, high frequency reuse cellular systems will have on providing the protection necessary to ensure interference-free operation of public safety systems operating in the 24 MHz of spectrum already allotted in the 746-806 MHz band. [7] Motorola maintains that in order to provide proper adjacent-channel protection to public safety services, the types of wider bandwidth technologies currently being deployed for

[7] Letter from Steve B. Sharkey, Motorola Inc., to Ms. Magalie Roman Salas, Secretary Federal Communications Commission, *Ex Parte* Notification – WT Docket No. 99-168 (Oct. 12, 1999).

commercial operations will not be able to operate within 1.5 MHz of the public safety services. Based on this, Motorola proposed a band plan that creates four 1.5 MHz band segments within each end of the 746-764 MHz and 776-794 MHz band segments. The 1.5 MHz band segments would be allocated to the Private Mobile Radio Service (PMRS). The remaining portions of the 746-764 MHz and 776-794 MHz would be allocated to the Commercial Mobile Radio Service (CMRS). This band plan would create a "transition region" between public safety and higher powered fixed and mobile commercial uses.

The Motorola Band Plan is based on the following analysis:

- The adjacent band emissions were modeled as a 1.25 MHz CDMA carrier. This is the widest of the existing technologies deployed in the cellular and PCS bands and could be used in the CMRS spectrum.

- The interference protection limit of the public safety receivers is at the same level as the noise floor of the receiver (-127 dBm). This is based on an I/N interference threshold of 0 dB. For an I/N=0 dB the increase in the public safety receiver noise floor would be:

$$C/N - C/N{+}I = 10\ \mathrm{Log}\ (10^{I/N/10} + 1) = 10\ \mathrm{Log}\ (10^{0} + 1) = 3\ \mathrm{dB}$$

  Using this interference protection limit would result in a 3 dB desensitization of the public safety receivers.

- The propagation loss is based on measured data from NEXTEL. For the 90% propagation loss curve the propagation loss was 75 dB. Using the 90% propagation curve means that 10% of the time the propagation loss will be below this value.

- Based on the parameters above the required adjacent band attenuation to protect public safety receivers is found to be:

$$P_{AdjBand} = 24 + 127 - 75 = 76\ \mathrm{dB}$$

- Assuming the existing roll-off of the CDMA emission mask in Part 24 of the Commission's Rules approximately 19 dB of additional attenuation would be required to protect public safety receivers.

The 1.5 MHz band segment allocated to PMRS would be used to provide a transition region for higher powered mobile and fixed commercial transmitters to attenuate their adjacent band emissions to a level adequate to protect public safety receivers. Motorola maintains its proposal will balance the concerns of spectrum efficiency and protection of public safety operations.

**FreeSpace Communications Band Plan**

The FreeSpace network is comprised of handsets and modems that transmit data and voice via a wireless link to small antennas that are mounted on either existing transmission towers or small base stations located on the roof tops of houses throughout a community. The base stations can be linked to the Internet through either wireline digital subscriber lines or other high speed Internet connections with an expected range of 0.5 miles. FreeSpace proposes that the Commission adopt the following channelization plan and power spectral density (PSD) limits in order to protect public safety receivers operating in the 764-776/794-806 MHz band[8]:

- Transmitters operating in four 1.5 MHz band segments adjacent to the public safety bands would be required to operate at a peak PSD that does not exceed 4 mW/kHz. If transmitting antennas of directional gain greater than 6 dBi are used, the peak PSD would be required to be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The PSD levels proposed by FreeSpace represent in-band limits for their systems. The attenuation of the emissions in the 764-776/794-806 MHz bands were not provided by FreeSpace. For a given distance separation the adjacent band emission limit of a single FreeSpace transmitter that is required to protect a public safety receiver can be determined using the following equation:

$$P_{AdjBand} = -I_T + P_T + G_T + G_R - 20 \text{ Log } F - 20 \text{ Log } D + 27.55 - L_{Clutter} - L_{CR} + 10 \text{ Log } DF$$

where

$I_T$ is the public safety receiver interference protection limit (dBm);
$P_T$ is the FreeSpace transmitter PSD (dBm/6.25 kHz);
$G_T$ is the FreeSpace transmitter antenna gain (dBi);
$G_R$ is the public safety receiver antenna gain (dBi);
F is the FreeSpace transmitter frequency (MHz);
D is the distance separation between the FreeSpace transmitter and the public safety receiver (m);
$L_{Clutter}$ is the clutter loss attenuation factor (dB);
$L_{CR}$ is the cable/insertion loss of the FreeSpace transmitter (dB);
DF is the transmitter duty factor.

Using the FreeSpace transmitter PSD limits of 4 mW/1 kHz (14 dBm/6.25 kHz) and an antenna gain for the FreeSpace transmitter of 6 dBi, a 20% duty factor, a frequency of 746 MHz, a nominal distance separation of 250 meters, and a clutter loss

[8] Letter from A. Richard Metzger, Jr., Ruth M. Milkman, and Charles W. Logan Counsel for FreeSpace Communications to Thomas J. Sugrue, Chief Wireless Telecommunications Bureau Federal Communications Commission, Written *Ex Parte* Communication Service Rules for the 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules WT Docket No. 99-168 (Oct. 13, 1999).

attenuation factor of 11 dB, the single entry adjacent band emission limits required to protect public safety receivers are computed below:

$$P_{AdjBand} = -(-134) + 14 + 6 + 0 - 57.45 - 47.9 + 27.55 - 11 - 2 - 6.98 = 57.2 \text{ dB}$$

Based on the envisioned high density use of fixed and mobile FreeSpace transmitters, the analysis of adjacent band emissions to protect public safety receivers must take into consideration the effect of aggregate interference from multiple FreeSpace transmitters. To compute the aggregate adjacent band attenuation the following equation will be used:

$$P_{AggAdjBand} = -I_T + P_T + G_T + G_R - 20 \text{ Log } F - 20 \text{ Log } D + 27.55 - L_{CR} - L_{Clutter} + 10 \text{ Log } N + 10 \text{ Log } DF$$

This equation is similar to the single entry equation above with the exception of the factor N, the number of transmitters in view of a public safety receiver. Making nominal assumptions that ten transmitters are in view of a public safety receiver each transmitting 20% of the time, the adjacent band emission limits for each transmitter that is required to protect public safety receivers assuming multiple transmitters are computed below:

$$P_{AggAdjBand} = -(-134) + 14 + 6 + 0 - 57.45 - 47.9 + 27.55 - 2 - 11 + 10 - 6.98 = 67.2 \text{ dB}$$

**CONCLUSIONS**

The adjacent band emission limits ultimately established for the transmitters operating in the 746-764/776-794 MHz bands will impact the use of this spectrum for commercial applications.

The adjacent band emission limits required to protect public safety operations will depend on the receiver protection limits, the characteristics of the adjacent band systems (e.g., transmitter power levels, antenna gains), and the scenarios considered (e.g., fixed, mobile).

Based on the receiver interference protection limits for public safety receivers, the assumed characteristics of the adjacent band transmitters, and the interference scenarios considered in this analysis, the following attenuation values are recommended to protect public safety receivers from adjacent band emissions of fixed and mobile transmitters:

- For transmitters with power levels above 1 Watt: 65 + 10 Log (Power)
- For transmitters with power levels below 1 Watt: 65 dBc (dB relative to the carrier)

The analysis performed by Motorola showed that additional attenuation will be required to protect public safety receivers from the adjacent band emissions of transmitters in the 746-764/776-794 MHz. In order to provide adequate protection for public safety receivers while maximizing the use of this spectrum for commercial applications, an approach similar to that proposed by Motorola could be employed.

Instead of creating a guard band of unused spectrum between a less compatible commercial service and the public safety spectrum this approach would allocate the spectrum adjacent to the public safety bands to a compatible service where the interference can be effectively managed. This would create a region over which the commercial service could attenuate their adjacent band emissions to the level required to protect public safety receivers, thereby minimizing the cost and impact to design of their systems.

Another approach was proposed where the spectrum adjacent to the 764-776/794-806 MHz public safety bands is allocated to a service employing low-powered transmitters. The interference to public safety receivers from these low-powered transmitters will depend on the adopted adjacent band emission limits and the number of devices operating in a given geographic area. To reduce the effects of aggregate interference, provisions could be included in the service rules that will ensure that the aggregate power of the transmitters never exceeds the power limits of a single transmitter. Limitations on transmitter duty cycle could also be established.

## ANNEX A
## ALGORITHM TO COMPUTE THE RECEIVER NOISE LEVEL

```
/* This algorithm is designed to compute the received noise power at
the receiver.
 * The atmospheric noise temperature, which is accounted for in the
antenna noise temperature
 * is first referenced to the receiver input through a cable with a
user entered loss. The
 * temperature is then added to the receiver noise temperature, which
is computed using the
 * receiver bandwidth and noise figure, to give the effective system
noise temperature. This
 * quantity is then converted to a noise power level.
 *                    Reference: Reference Data for Engineers - Chapter
34 and Recommendation ITU-R PI.372-6.

 */

#include <iostream.h>
#include <math.h>
#include <conio.h>
#include <graph.h>
#include <stdlib.h>
#include <iomanip.h>
#include <fstream.h>
#include <stdio.h>
#include <io.h>

void main()
{
        double Trcvr;                                /* Receiver noise
temperature */
        double Tsys;                                 /* System noise
temperature */
        double k=1.38*pow(10.0,-23.0);               /* Boltzman's constant
*/
        double To = 290.;                            /* Reference (ambient)
temperature */
        double TatmosdB;                             /* Atmospheric noise
temperature */
        double Tantenna;                             /* Antenna noise
temperature */
        double Tant_at_rcvr;                         /* Antenna noise
temperature referenced to receiver */
        double F;                                    /* Noise figure in dB =
10*log(1+Trcvr/To) */
        double nfactor;                              /* Noise factor - noise
figure converted to fraction */
        double Loss_cable;                           /* Cable loss in dB */
        double Cable_loss;                           /* Cable loss converted
to fraction */
        double BW;                                   /* Receiver bandwidth in
KHz */
        double fo;                                   /* Receiver tuned
frequency in MHz */
```

```
        double Signal_to_Noise_Threshold;
        double Minimum_Signal_Level_at_Antenna_Terminals;
        double Minimum_Signal_Level_at_Receiver;
        double Antenna_Noise_Power_at_Receiver;
        double Cable_Noise_Power_at_Receiver;
        double Receiver_Noise_Power;
        double ANPR_in_dBm;
        double CNPR_in_dBm;
        double RNP_in_dBm;
        double Comb_Cab_and_Ant_Noise_Power_in_dBm;
        double Total_Noise_Power;
        double System_Noise_Power_in_dBm;
        double Natm;
        long Loc_Code;

        printf("Enter tuned frequency receiver, in MHz: ");
        scanf("%lf", &fo);
        printf("Enter receiver bandwidth, in KHz: ");
        scanf("%lf", &BW);
        printf("Enter receive cable loss, in dB: ");
        scanf("%lf", &Loss_cable);
        printf("Enter receiver noise figure, in dB: ");
        scanf("%lf", &F);
        printf("Enter location code: 1) Rural:,  2) Residential:,  3)
Urban: ");
        scanf("%ld", &Loc_Code);


if(fo >= 0.000001 && fo < .00001)                    /* 1 Hz to 10 Hz */
        Natm = 267. - 30.*log10(fo/0.000001);

if(fo >= 0.00001 && fo < 0.0001)                     /* 10 Hz to 100 Hz
*/
        Natm = 237. - 27.*log10(fo/0.00001);

if(fo >= 0.0001 && fo < 0.000316)                    /* 100 Hz to 316 Hz
*/
        Natm = 210. - 30.0*log10(fo/0.0001);

if(fo >= 0.000316 && fo < 0.001)                      /* 316 Hz to 1 KHz
*/
        Natm = 195. - 60.0*log10(fo/0.000316);

if(fo >= 0.001 && fo < 0.00316)                       /* 1 KHz to 3.16
KHz */
        Natm = 165. - 20.0*log10(fo/0.001);

if(fo >= 0.00316 && fo < 0.01)                        /* 3.16 KHz to 10
KHz */
        Natm = 155. + 16.0*log10(fo/0.00316);

if(fo >= 0.01 && fo < 0.1)                            /* 10 KHz to 100
KHz */
        Natm = 163.0 - 53.0*log10(fo/0.01);

if(fo >= 0.1 && fo < 1.)                              /* 100 KHz to 1 MHz
*/
```

```
        Natm = 110.0 - 37.5*log10(fo/0.1);

if(fo >= 1.0 && fo < 10.0)                          /* 1 MHz to 10 MHz
*/
        Natm = 72.5 - 32.5*log10(fo/1.);

if(fo >= 10. && fo < 31.6)                          /* 10 MHz to 31.6
MHz */
        Natm = 40.0 - 30.0*log10(fo/10.);

if(fo >= 31.6 && fo < 100.)                         /* 31.6 MHz to 100
MHz */
        Natm = 25. -20.0*log10(fo/31.6);

if(fo >= 100. && fo < 1000.)                        /* 100 MHz to 1 GHz
*/
        Natm = 15. - 25.*log10(fo/100.);

if(fo >= 1000.)                                      /* 1 GHz to    */
        Natm = -11.;

if(Loc_Code == 1 )
Natm = Natm - 6.0;

if(Loc_Code == 3)
Natm = Natm + 5.0;


/* Converting the cable loss in dB to a real number. */
Cable_loss = pow(10,Loss_cable/10);


/* Converting the noise figure to noise factor */
nfactor = pow(10,F/10);


/* Computing the receiver noise temperature using: noise factor = 1
+Trcvr/To */
Trcvr = To*(nfactor - 1);


/* Converting atmospheric noise level to an antenna temperature */
TatmosdB = Natm - 204. + 10*log10(BW*1000.);


Tantenna = (pow(10,TatmosdB/10))/(k*BW*1000.);


Antenna_Noise_Power_at_Receiver = (k*Tantenna*BW*1000.)/Cable_loss;

ANPR_in_dBm = 10*log10(Antenna_Noise_Power_at_Receiver) + 30.;

Cable_Noise_Power_at_Receiver = k*To*BW*1000.*(Cable_loss-
1)/Cable_loss;

CNPR_in_dBm = 10*log10(Cable_Noise_Power_at_Receiver) + 30.;
```

```
Receiver_Noise_Power = k*To*BW*1000.*(nfactor - 1);

RNP_in_dBm = 10*log10(Receiver_Noise_Power) + 30.;

Comb_Cab_and_Ant_Noise_Power_in_dBm =
10*log10(Antenna_Noise_Power_at_Receiver +
Cable_Noise_Power_at_Receiver) + 30.;

Total_Noise_Power = Antenna_Noise_Power_at_Receiver +
Cable_Noise_Power_at_Receiver + Receiver_Noise_Power;
System_Noise_Power_in_dBm = 10*log10(Total_Noise_Power) + 30.;

/* Referencing antenna temperature to receiver input */
Tant_at_rcvr = ((Cable_loss - 1.)*290 + Tantenna)/Cable_loss;

/* Total system noise temperature */
Tsys = Trcvr + Tant_at_rcvr;

//                              OUTPUT
printf("                                                \n");

printf("-------------------NOISE PROGRAM RESULTS ---------------------
\n\n\n");

printf("Environmental Noise Level above kToBn (dB): %.2lf\n\n", Natm);

printf("Antenna Noise Temperature (K): %.2lf\n\n", Tantenna);

printf("Antenna Noise Temperature at Receiver (K): %.2lf\n\n",
Tant_at_rcvr);

printf("Receiver Noise Temperature (K): %.2lf\n\n", Trcvr);

printf("System Noise Temperature (K): %.2lf\n\n", Tsys);

printf("Antenna Noise Power at Receiver (W): %e\n\n",
Antenna_Noise_Power_at_Receiver);

printf("                       Press <ENTER> to Continue            \n\n");

_getch();                        /* pauses the output until the user hit
s a key. */

printf("Cable Noise Power at Receiver (W): %e\n\n",
Cable_Noise_Power_at_Receiver);

printf("Receiver Noise Power (W): %e\n\n", Receiver_Noise_Power);

printf("Total Noise Power (W): %e\n\n", Total_Noise_Power);

printf("Antenna Noise Power at Receiver (dBm): %.2lf\n\n",
ANPR_in_dBm);

printf("Cable Noise Power at Receiver (dBm): %.2lf\n\n", CNPR_in_dBm);

printf("Cable + Antenna Noise at Receiver (dBm): %.2lf\n\n",
Comb_Cab_and_Ant_Noise_Power_in_dBm);
```

```
printf("Receiver Noise Power (dBm): %.2lf\n\n", RNP_in_dBm);

printf("Total System Noise Power (dBm): %.2lf\n",
System_Noise_Power_in_dBm);

}
```

Before the
Federal Communications Commission
Washington, D.C. 20554

**Certificate of Service**

| | | |
|---|---|---|
| In the Matters of<br><br>Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules | ) | WT Docket No. 99–168 |
| and | ) | |
| The Development of Operational, Technical and Spectrum Requirements For Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010 | ) | WT Docket No. 96–86 |

I, David A. Williams, Senior Associate, Booz·Allen & Hamilton, Inc., 8283 Greensboro Drive, McLean, Virginia, 22102-3838, hereby certify that on this date I caused to be served, by first-class mail, postage prepaid (or by hand where noted) copies of the Federal Law Enforcement Wireless Users Group's ex parte comments regarding the Commission's Notice of Proposed Rulemaking *In the Matter of Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules* and its First Report and Order *In the Matter of the Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010*, the original of which is filed herewith and upon the parties identified on the attached service list.

DATED at Fair Oaks, Virginia this 10th day of December, 1999.

David A. Williams

**Service List**

*The Honorable William E. Kennard, Chairman
Federal Communications Commission
445 12th St., S.W., Rm. 8-B201
Washington, D.C. 20054

*The Honorable Harold Furchgott-Roth, Commissioner
Federal Communications Commission
445 12th St., S.W., Rm. 8-A302
Washington, D.C. 20054

*The Honorable Susan Ness, Commissioner
Federal Communications Commission
445 12th St., S.W., Rm. 8-B115
Washington, D.C. 20054

*The Honorable Michael Powell, Commissioner
Federal Communications Commission
445 12th St., S.W., Rm. 8-A204
Washington, D.C. 20054

*The Honorable Gloria Tristani, Commissioner
Federal Communications Commission
445 12th St., S.W., Rm. 8-C302
Washington, D.C. 20054

*Ari Fitzgerald, Legal Advisor
Office of Chairman Kennard
Federal Communications Commission
445 12th St., S.W., Rm. 8-B201
Washington, D.C. 20054

*Paul E. Misener, Senior Legal Advisor
Office of Commissioner Furchgott-Roth
Federal Communications Commission
445 12th St., S.W., Rm. 8-A302
Washington, D.C. 20054

*Daniel Connors, Legal Advisor
Office of Commissioner Ness
Federal Communications Commission
445 12th St., S.W., Rm. 8-B115
Washington, D.C. 20054

*Peter A. Tenhula
Office of Commissioner Powell
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 8-A204
Washington, D.C. 20054

*Karen L. Gulick
Office of Commissioner Tristani
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 8-C302
Washington, D.C. 20054

*Thomas J. Sugrue, Chief
Wireless Telecommunications Bureau
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C252
Washington, D.C. 20054

*Kathleen O'Brien-Ham, Deputy Chief
Wireless Telecommunications Bureau
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C207
Washington, D.C. 20054

*James D. Schlichting, Deputy Chief
Wireless Telecommunications Bureau
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C207
Washington, D.C. 20054

*D'Wana R. Terry, Chief
Public Safety & Private Wireless Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 4-C321
Washington, D.C. 20054

*Ramona Melson, Chief Legal Counsel
Public Safety & Private Wireless Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 4-C321
Washington, D.C. 20054

*Herb Zeiler
Public Safety & Private Wireless Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 4-C321
Washington, D.C. 20054

*Katherine Hosford
Public Safety & Private Wireless Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 4-C321
Washington, D.C. 20054

*Kris Monteith, Chief
Policy Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C120
Washington, D.C. 20054

*Nancy, Boocker, Deputy Chief
Policy Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C120
Washington, D.C. 20054

*Stan Wiggins
Policy Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C120
Washington, D.C. 20054

*Ed Jacobs
Policy Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 3-C120
Washington, D.C. 20054

*Steve Weingarten, Chief
Commercial Wireless Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 4-C207
Washington, D.C. 20054

*Jeff Steinberg, Deputy Chief
Commercial Wireless Division
Federal Communications Commission
445 12$^{th}$ St., S.W., Rm. 4-C207
Washington, D.C. 20054

International Transcription Services, Inc.
1231 20$^{th}$ St. N.W.
Washington, D.C. 20037

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